We claim:

1. A method of demodulating a real two-dimensional pattern, the method comprising the steps of:

estimating a quadrature two-dimensional pattern from said real two-dimensional pattern using a two-dimensional spiral phase filter; and

creating a demodulated image by combining said real two-dimensional pattern and said estimated quadrature two-dimensional pattern.

2. A method as claimed in claim 1, wherein said estimating step includes the steps of:

generating a frequency domain signal from said real two-dimensional pattern using a linear transform;

applying said two-dimensional spiral phase filter to at least part of said frequency domain signal to provide a filter signal;

generating a spatial domain pattern from said filtered signal using an inverse of said linear transform; and

extracting from the spatial domain pattern an estimate of said quadrature two-dimensional pattern.

3. A method as claimed in claim 1, wherein said estimating step includes the steps of:

convolving said real two-dimensional pattern with a complex function to provide a convolved spatial domain pattern, said complex function being an inverse Fourier transform of said two-dimensional spiral phase filter; and

extracting from the spatial domain pattern an estimate of said imaginary two-dimensional pattern.

4. A method as claimed in claim 2, wherein the extracting step further includes determining an approximate orientation angle of at least one fringe pattern in said spatial domain pattern.

5. A method as claimed in claims 4 wherein determining said approximate orientation angle of at least one fringe pattern in said spatial domain pattern step comprises the steps of:

applying a complex energy operator to the image to provide an energy encoded image;

determining a phase component of said energy encoded image; and

calculating said orientation angle from said phase component of said energy encoded image.

6. A method as claimed in claim 5 wherein said complex energy operator is defined as:

$$\Psi_c\{f\} = \left(D\{f\}\right)^2 - fD^2\{f\}$$

and said phase component of said energy encoded image is defined as:

$$2\beta_0 = \arg\left(\Psi_c\{f\}\right)$$

7. A method as claimed in claim 5 wherein said complex energy operator is a modified complex energy operator defined as,

$$\Psi_M\{f\} = (D_M\{f\})^2 - fD_M^2\{f\}$$

and said phase component of said energy encoded image is defined as:

$$2\beta_0 = \arg\left(\Psi_M\{f\}\right)$$

8. A method as claimed in claim 5 wherein said image is pre-processed to remove background offsets.

9. Apparatus for demodulating a real two-dimensional pattern, the apparatus comprising:

means for estimating a quadrature two-dimensional pattern from said real two-dimensional pattern using a two-dimensional spiral phase filter; and

means for creating a demodulated image by combining said real two-dimensional pattern and said estimated quadrature two-dimensional pattern.

10. Apparatus as claimed in claim 9, wherein said means for estimating an imaginary two-dimensional pattern includes:

means for generating a frequency domain signal from said real two-dimensional pattern using a linear transform;

means for applying said two-dimensional spiral phase filter to at least part of said frequency domain signal to provide a filter signal;

means for generating a spatial domain pattern from said filtered signal using an inverse of said linear transform; and

means for extracting from the spatial domain pattern an estimate of said quadrature two-dimensional pattern.

11. Apparatus as claimed in claim 9, wherein said means for estimating an imaginary two-dimensional pattern includes:

means for convolving said real two-dimensional pattern with a complex function to provide a convolved spatial domain pattern, said complex function being an inverse Fourier transform of said two-dimensional spiral phase filter; and

means for extracting from the spatial domain pattern an estimate of said imaginary two-dimensional pattern.

12. Apparatus as claimed in claim 10 or 11, wherein the extracting means further includes means for determining an approximate orientation angle of at least one fringe pattern in said spatial domain pattern.

13. Apparatus as claimed in claims 12 wherein said means for determining said approximate orientation angle of at least one fringe pattern in said spatial domain pattern comprises:

means for applying a complex energy operator to the image to provide an energy encoded image;

means for determining a phase component of said energy encoded image; and

means for calculating said orientation angle from said phase component of said energy encoded image.

14. Apparatus for calculating a quadrature conjugate of a real two-dimensional code pattern, the apparatus comprising:

a first spatial light modulator for modulating coherent light to produce said real two-dimensional pattern;

a first lens for Fourier transformation of said real two-dimensional pattern to produce a first Fourier transformed image;

a second spatial light modulator or spiral phase plate for phase modulating said first Fourier transformed image to produce a phase modulated image;

a second lens for Fourier transformation of said phase modulated image to produce a second Fourier transformed image;

a third spatial light modulator or spiral phase plate for phase modulating said second Fourier transformed image to produce said conjugate of said real two-dimensional pattern; and

an image sensor for capturing said conjugate of said real two-dimensional pattern.

15. A method of estimating an orientation angle of a pattern in an image, said method comprising the steps of:

applying a complex energy operator to the image to provide an energy encoded image;

determining a phase component of said energy encoded image; and

calculating said orientation angle from said phase component of said energy encoded image.

16. A method as claimed in claim 15 wherein said complex energy operator is defined as:

$$\Psi_c\{f\} = \left(D\{f\}\right)^2 - fD^2\{f\}$$

and said phase component of said energy encoded image is defined as:

$$2\beta_0 = \arg\left(\Psi_c\{f\}\right)$$

17. A method as claimed in claim 15 wherein said complex energy operator is a modified complex energy operator defined as:

$$\Psi_M\{f\} = (D_M\{f\})^2 - fD_M^2\{f\}$$

and said phase component of said energy encoded image is defined as:

$$2\beta_0 = \arg\left(\Psi_M\{f\}\right)$$

18. A method as claimed in claim 15 wherein said image is pre-processed to remove background offsets.

19. Apparatus for estimating an orientation angle of a pattern in an image, said apparatus comprises:

means for applying a complex energy operator to the image to provide an energy encoded image;

means for determining a phase component of said energy encoded image; and

means for calculating said orientation angle from said phase component of said energy encoded image.

20. Apparatus as claimed in claim 19 wherein said complex energy operator is defined as:

$$\Psi_c\{f\} = \left(D\{f\}\right)^2 - fD^2\{f\}$$

and said phase component of said energy encoded image is defined as:

$$2\beta_0 = \arg\left(\Psi_c\{f\}\right)$$

21. Apparatus as claimed in claim 19 wherein said complex energy operator is a modified complex energy operator defined as:

$$\Psi_M\{f\} = (D_M\{f\})^2 - fD_M^2\{f\}$$

and said phase component of said energy encoded image is defined as:

$$2\beta_0 = \arg\left(\Psi_M\{f\}\right)$$

22. Apparatus as claimed in claim 19, said apparatus further comprising a means for pre-processing said image to remove background offsets.

23. A method of estimating relative phase shifts between fringe pattern images in a sequence of phase-related fringe patterns, said method comprising the steps of:

a) removing offsets from each of said fringe pattern images to obtain pure AMFM patterns;

b) determining contingent analytic images corresponding to each of said AMFM patterns;

c) determining phase differences from dependent pairs of said contingent analytic images; and

d) estimating phase shifts between pairs of said contingent analytic images, wherein said phase shifts between pairs of said contingent analytic images are said relative phase shifts between fringe pattern images.

24. A method as claimed in claim 23 wherein said removing step is performed by calculating interframe difference images between pairs of said fringe pattern images.

25. A method as claimed in claim 23 wherein said contingent analytic images comprise complex images with said AMFM patterns as imaginary parts and imaginary parts of a vortex operator applied to said AMFM patterns in said real parts

26. A method as claimed in claim 23 further comprising the steps of:

e) estimating a spatial phase of said fringe pattern images;

f) estimating an amplitude modulation and said offset of said fringe pattern images;

g) determining an accuracy measure of said contingent analytic images from said estimated amplitude modulation, offset and spatial phase;

h) determining a weighting function wherein areas of low accuracy measure are given a low weighting; and

i) iteratively repeating steps d) to h) by applying said weighting function in step d), until said accuracy measure is above a predetermined quantity.

27. A method as claimed in claim 26 wherein said accuracy measure determination step is performed by comparing one of said analytic images with a reconstructed fringe pattern, wherein said reconstructed fringe pattern is reconstructed using said estimated amplitude modulation, offset and spatial phase.

28. A method of estimating a spatial phase of fringe pattern images in a sequence of fringe patterns, said method comprising the steps of:

a) removing offsets from each of said fringe pattern images to obtain pure AMFM patterns;

b) determining contingent analytic images corresponding to each of said AMFM patterns;

c) determining phase differences from dependent pairs of said contingent analytic images;

d) estimating phase shifts between pairs of said contingent analytic images; and

e) estimating a spatial phase of said fringe pattern images.

29. A method as claimed in claim 28 wherein said removing step is performed by calculating interframe difference images between pairs of said fringe pattern images.

30. A method as claimed in claim 28 wherein said contingent analytic images comprise complex images with said AMFM patterns as imaginary parts and imaginary parts of a vortex operator applied to said AMFM patterns in said real parts.

31. A method as claimed in claim 28 further comprising the steps of:

f) estimating an amplitude modulation and said offset of said fringe pattern images;

g) determining an accuracy measure of said contingent analytic images from said estimated amplitude modulation, offset and spatial phase;

h) determining a weighting function wherein areas of low accuracy measure are given a low weighting; and

i) iteratively repeating steps d) to h) by applying said weighting function in step d), until said accuracy measure is above a predetermined quantity.

32. A method as claimed in claim 31 wherein said accuracy measure determination step is performed by comparing one of said analytic images with a reconstructed fringe pattern, wherein said reconstructed fringe pattern is reconstructed using said estimated amplitude modulation, offset and spatial phase.

33. A method as claimed in claim 23 wherein an intensity of said fringe pattern images are in the form:

$$f_n(x,y) = a(x,y) + b(x,y)\cos[\chi(x,y) + \delta_n]$$

wherein $a(x,y)$ is said offset, $b(x,y)$ is said amplitude modulation $\chi(x,y)$ is said spatial phase and δ_n is a phase shift parameter.

34. Apparatus for estimating relative phase shifts between fringe pattern images in a sequence of phase-related fringe patterns, said apparatus comprising:

means for removing offsets from each of said fringe pattern images to obtain pure AMFM patterns;

means for determining contingent analytic images corresponding to each of said AMFM patterns;

means for determining phase differences from dependent pairs of said contingent analytic images; and

means for estimating phase shifts between pairs of said contingent analytic images, wherein said phase shifts between pairs of said contingent analytic images are said relative phase shifts between fringe pattern images.

35. Apparatus as claimed in claim 34 wherein said means for removing offsets comprises means for calculating interframe difference images between pairs of said fringe pattern images.

36. Apparatus as claimed in claim 34 wherein said contingent analytic images comprise complex images with said AMFM patterns as imaginary parts and imaginary parts of a vortex operator applied to said AMFM patterns in said real parts.

37. Apparatus as claimed in claim 34 further comprising:

means for estimating a spatial phase of said fringe pattern images;

means for estimating an amplitude modulation and an offset of said fringe pattern images;

means for determining an accuracy measure of said contingent analytic images from said estimated amplitude modulation, offset and spatial phase;

means for determining a weighting function wherein areas of low accuracy measure are given a low weighting; and

iterative means for providing said weighting function to said means for estimating phase shifts, until said accuracy measure is above a predetermined quantity.

38. Apparatus as claimed in claim 37 wherein said means for determining an accuracy measure comprises a comparator for comparing one of said analytic images with a reconstructed fringe pattern, wherein said reconstructed fringe pattern is reconstructed using said estimated amplitude modulation, offset and spatial phase.

39. Apparatus for estimating a spatial phase of fringe pattern images in a sequence of fringe patterns, said apparatus comprising:

means for removing offsets from each of said fringe pattern images to obtain pure AMFM patterns;

means for determining contingent analytic images corresponding to each of said AMFM patterns;

means for determining phase differences from dependent pairs of said contingent analytic images;

means for estimating phase shifts between pairs of said contingent analytic images; and

means for estimating a spatial phase of said fringe pattern images.

40. Apparatus as claimed in claim 39 wherein said means for removing offsets comprises means for calculating interframe difference images between pairs of said fringe pattern images.

41. Apparatus as claimed in claim 39 wherein said contingent analytic images comprise complex images with said AMFM patterns as imaginary parts and imaginary parts of a vortex operator applied to said AMFM patterns in said real parts.

42. Apparatus as claimed in claim 39 further comprising:

means for estimating an amplitude modulation and an offset of said fringe pattern images;

means for determining an accuracy measure of said contingent analytic images from said estimated amplitude modulation, offset and spatial phase;

means for determining a weighting function wherein areas of low accuracy measure are given a low weighting; and

iterative means for providing said weighting function to said means for estimating phase shifts, until said accuracy measure is above a predetermined quantity.

43. Apparatus as claimed in claim 42 wherein said means for determining an accuracy measure comprises a comparator for comparing one of said analytic images with a reconstructed fringe pattern, wherein said reconstructed fringe pattern is reconstructed using said estimated amplitude modulation, offset and spatial phase.

44. Apparatus as claimed in claim 34 wherein said fringe pattern images are in the form:

$$f_n(x,y) = a(x,y) + b(x,y)\cos[\chi(x,y) + \delta_n]$$

wherein $a(x,y)$ is said offset, $b(x,y)$ is said amplitude modulation $\chi(x,y)$ is said spatial phase and δ_n is a phase shift parameter.